APPENDIX E

Incremental Cost Analysis

C-088945

SECTION 1135 PROJECT MODIFICATION REPORT

PROSPECT ISLAND, CALIFORNIA

COST EFFECTIVENESS AND INCREMENTAL COST ANALYSIS
of
Restoration Alternatives

U.S. Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, California 95814-2922

August 1997

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1.0 Introduction.

This report presents the cost effectiveness and incremental cost analysis of alternative restoration plans for Prospect Island. The purpose of this analysis is to provide decision makers with a tool to evaluate restoration alternatives. Cost effectiveness analysis helps in the formulation of cost-effective alternative plans by screening out plans that are not cost effective from further study. Incremental cost analysis is used to show the changes in costs as levels of environmental output are increased. Also reported here are discussions of habitat values that would be gained, descriptions of the restoration measures and alternatives, and costs of the various alternatives. Guidance for preparing these analyses came from EC (Engineering Circular) 1105-2-206, EC 1105-2-210, and EC 1165-2-201 and Institute for Water Resources Report 94-PS-2.

2.0 Purpose and Need for the Project.

Corp projects adjacent to Prospect Island and upstream projects in the watershed have directly, indirectly, and cumulatively contributed to fish and wildlife habitat losses. Past Corps projects have allowed agriculture to develop in the Delta, which has contributed to the loss of important habitat. Implementation of Prospect Island habitat restoration provides a way for SRA, riparian, and freshwater tidal wetland habitat to be restored while reducing the Corps maintenance cost on the ship channel. Prospect Island is contiguous to the Corps ship channel and a Sacramento River Flood Control Project levee along Miner Slough and is affected by numerous upstream dams that provide flood protection.

3.0 Site Description.

Prospect Island is located in Solano County in the northern portion of the Sacramento-San Joaquin Delta (Delta). The project area includes: (a) a 1,316 acre parcel of Prospect Island recently purchased from the Sakata Brothers, (b) surrounding levees owned by the Port of Sacramento, and (c) overwater shade cover provided by trees growing on the outboard side of the levees. The area is bounded to the east by Miner Slough, the west by the Sacramento River Deep Water Ship Channel (ship channel), the south by a levee at about ship channel mile 20 and the north by an east-west levee from Arrowhead Harbor (formerly Five Points Marina) to the ship channel (Figure 1b). With the exception of limited areas near the levees, the topography of the island is generally flat, varying from 0 feet mean sea level (MSL) in the northern third to -3 feet MSL in southern portions of the site. Mean water level (MWL) in nearby Shag Slough is about 2 feet above MSL, which, if applied to Miner Slough would place most of Prospect Island at -2 to -5 feet MWL. This is considered a relatively modest degree of subsidence (DWR 1993)

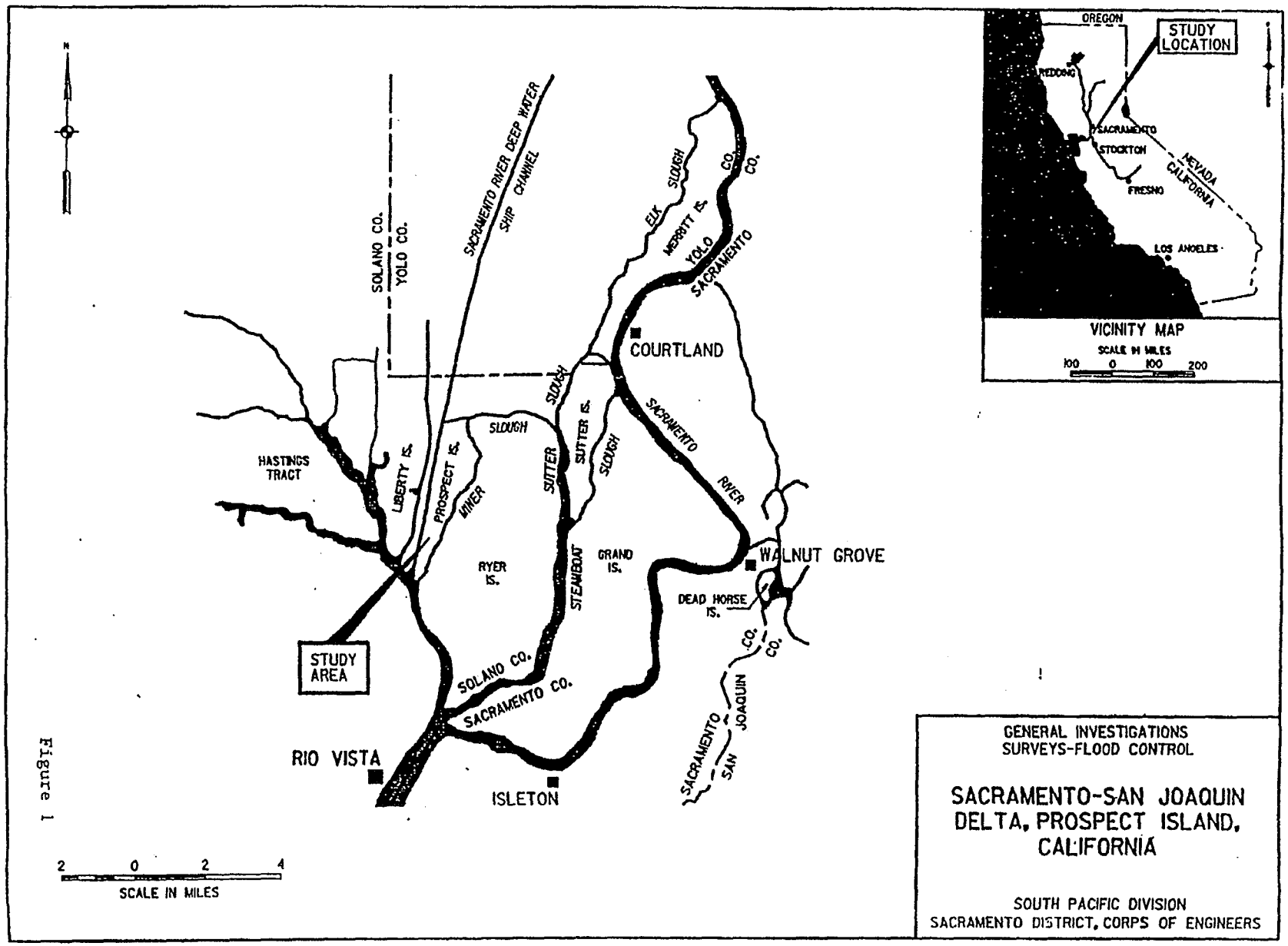


Figure 1

4.0 Restoration Objectives.

The overall goal of the proposed Prospect Island project is to restore tidal wetlands and adjacent riparian ecosystems. A second goal is to increase the numbers and diversity of wildlife dependent on these ecosystems, including species of special concern. Specific objectives for this project were developed using habitat deficiencies identified by resource managers from the Department of Water Resources, Fish and Wildlife Service, and the Corps of Engineers.

- Create habitat suitable for Federally-listed threatened Delta smelt habitat and proposed threatened Sacramento splittail on Prospect Island,
- Develop feeding, cover, and resting areas for Federally-listed endangered winter-run chinook salmon on Prospect Island,
- Improve waterfowl and shorebird habitat on Prospect Island,
- Provide terrestrial and aquatic habitat for other wildlife species

5.0 Restoration Alternatives.

Flooding Background. This document was written assuming that Prospect Island is constructed in the dry. During the plan formulation phase of this study, the island flooded Flooding on Prospect has occured seven times in the last 17 years. In six of these events, the levees were repaired, the island pumped dry, and prepared for agriculture. The levees breached along Miner Slough during January 1997. The cross levee separating the Port's and Reclamation's property also breached. The construction of the proposed action is based on Prospect Island being dry and the levee's intact. The Bureau of Reclamation will make temporary repairs to the Miner Slough breach in the summer of 1997. The Port also plans to permanently repair their breaches along Miner Slough in 1997, after which Prospect Island can be pumped dry. Reclamation will then permanently repair the cross levee prior to Corps construction in 1998.

Baseline Alternative Formulation. The alternatives examined in this study involve the creation of interior islands constructed in the dry. Although similar in concept, the alternatives differ in complexity, expense, and level of development. Islands have been designed to provide wildlife habitat and reduce fetch lengths and associated wind generated waves. In addition, the alternatives incorporate methods to stabilize interior levees through the use of biotechnical plantings. In each alternative, levees are breached to allow full tidal action to return to Prospect Island. The levee breaches have all been designed to allow a 1- or 2-day replacement of water at the site.

After completion of the construction, a three year monitoring program will be established to evaluate the following elements: Fisheries, wildlife, vegetation, water quality, zooplankton, phytoplankton, benthos, and bathymetry.

Using a $1.25 million endownment fund issued by DWR by Category III, the FWS would accept responsibilty for the operation and maintenance of Prospect Island after construction.

No Action. Under without-project conditions, no action would be taken by the Federal Government to improve environmental values of Prospect Island. The without-project assumptions related to the existing navigation and flood control facilities and current land uses are:

- The land would continue to be owned by Reclamation.
- The land would continue to be farmed. Reclamation would not restore Prospect Island and they would continue to lease it out for agriculture.
- No habitat restoration features would be constructed.
- The Corps would continue to expend an average of more than $300,000 per year for maintenance of the ship channel levee at Prospect Island.

Alternatives One and Two were screened out during the reconnaissance phase of this study due to implemetation concerns. The remaining three alternative were evaluated in this analysis.

Alternative 3. This alternative provides more terrestrial habitat than open water habitat and is similar to a natural tidal system with channels of varying widths, undercut banks, channels through islands, depressions on the tops of islands to impound ponds at low tide, and small embayments for fish. Cover type acreage is for this alternative is listed in Table 4.

Alternative 4. This alternative would be achieved by constructing eight large elongated islands and a channel, and depositing additional bench material along the perimeter to fortify existing levees. The islands would be built using material from the site to create the interior channels. Two 300 foot breaches would be created, one at the southern end of the site along the ship channel and one on the northern end of the site along Miner Slough. Cover type acreage is for this alternative is listed in Table 4

Alternative 5. This alternative would be achieved by constructing eight large elongated islands and a channel, and depositing additional bench material along the perimeter to fortify existing levees. The islands would be built using material from the site to create the interior channels. Two 300 foot breaches would be created at the southern end of the site; one on the ship channel and one on Miner Slough. Construction will take place in the dry over a one year construction period. Cover type acreage is for this alternative is listed in Table 4

6.0 Data Evaluated.

The benefits (environmental outputs) of the restoration alternatives were quantified using HEP (Habitat Evaluation Procedures). HEP is a methodology developed by the U.S. Fish and Wildlife Service which can be used to document the quality and quantity of available habitat for selected fish and wildlife species or communities. HEP provides information for two general types of comparisons: (1) the relative value of different areas at the same point in time and (2) the relative value of the same area at different points in time. By combining the two types of comparisons, the impacts of proposed or anticipated land-use and water-use changes on habitat can be quantified. The output units of a HEP analysis are termed habitat units and average annual habitat units (AAHU's) (habitat units annualized over the project life). Appendix B of the U.S. Fish and Wildlife Service's Coordination Act Report contains the results of the HEP analysis for this project, including all assumptions and calculations. It also contains the output of each restoration alternative in terms of AAHUs. Table 1 provides the Habitat and Acreage Increases for Alternative 3, 4, and 5, and table 2 illustrates the features, costs, and output.

Preliminary cost estimate for alternatives were developed by the Sacramento District's Engineering Division.

Table 1. Habitat and Acreage Increases for Alternatives.

Cover Type	Acres Alternative 3	AAHU's Alternative 3	Acres Alternative 4	AAHU's Alternative 4	Acres Alternative 5	AAHU's Alternative 5
Riparian	192.6	97.3	33.5	30	33.5	30
SRA	25.0	18.7	0	0	0	0
SPA	0	0	16.4	10.5	16.4	10.5
Tidal Open Water	489	270.6	665	368	665	368
Tidal Emergent Marsh	297.0	282.4	300.6	173.6	300.6	173.6
Mudflat	246.0	220.4	234	194.5	234	194.5
Upland	15.0	10.3	-15.1	-8.3	0	0
Bare Ground	0	0	-10.0	0	-10.0	0
Total Net Gain	1264.6	899.7	1224.4	768.3	1,249.5	776.6
Total First Cost (Millions)	$7,368,638.00		$4,081,800.00		$4,081,800.00	

Table 2. Features, Costs (average annual), and Output of Restoration Alternatives.

Restoration Alternatives	Features	Average Annual Cost (X 1,000)	Output (AAHUs)
1	No Action	$0.00	0.0
3	Cover types noted in Table 1	$7,368,638.00	899.7
4		$4,081,800.00	768.3
5		$4,081,800.00	776.6

7.0 Cost Effectiveness Analysis.

This analysis identifies least-cost solution for each possible level of restoration output. Three criteria were used to identify non-cost effective alternatives:

1. *The same output level could be produced by another alternative at less cost;*

2. *A larger output level could be produced at the same cost;*

3. *A larger output level could be produced at less cost.*

Table 3 shows the cost effectiveness analysis process. First, the alternatives were ranked in order of increasing output. Next, alternatives were evaluated using the three criteria listed above. Notice that Alternative 5 produces a larger output level at less cost (criteria 3) than Alternative 4 (shaded). In other words, Alternative 4 was non-cost effective. As a result, it was eliminated from further consideration. Alternative 3 and 5 remained in the analysis.

Table 3. Cost Effectiveness Analysis (Alternatives sorted by Cost and Output).

Restoration Alternatives	Average Annual Cost (X 1,000)	Output (AAHUs)
1 (no action)	$ 0.0	0.0
4	$4,081,800	768.3
5	$4,081,800	776.6
3	$7,368,638	899.7

8.0 Incremental Analysis.

Incremental analysis is a procedure for showing the differences in costs and output between alternatives. Table 4 displays the cost, output, incremental cost, incremental output, and incremental average cost for each successive alternative. The alternatives are arranged in order of increasing output (AAHU's). The incremental cost of an alternative is the change in cost resulting from the decision to implement one alternative instead of another. For example, the incremental cost of alternative 5 (over alternative 3) is the difference in cost between the two alternatives:

$$\text{Incremental Cost Per Unit}_i = \frac{\text{Cost}_i - \text{Cost}_{pp}}{\text{Output}_i - \text{Output}_{pp}}$$

Where:
PP = previous alternative; and
I = alternative under consideration

The incremental output is computed in the same manner. The incremental average cost is the difference in the cost per habitat unit (average cost) between two alternatives.

Table 4. Cost Effective Least Cost Alternatives with Incremental Analysis.

Alternative	Cost (X $1,000)	Output (AAHU's)	Incremental Cost (X $1,000)	Incremental Output (AAHU's)	Incremental Average Cost (X $1,000 / AAHU)
1	0	0	n/a	n/a	n/a
5	4081800.00	776.60	4081800.00	776.60	5255.99
3	7368638.00	899.70	3286838.00	123.10	26700.55

Next, the cost per unit of moving from the "No-Action" alternative to each remaining alternative was calculated as follows:

$$\text{Incremental Cost Per Unit}_i = \frac{\text{Cost}_i - \text{Cost}_{NA}}{\text{Output}_i - \text{Output}_{NA}}$$

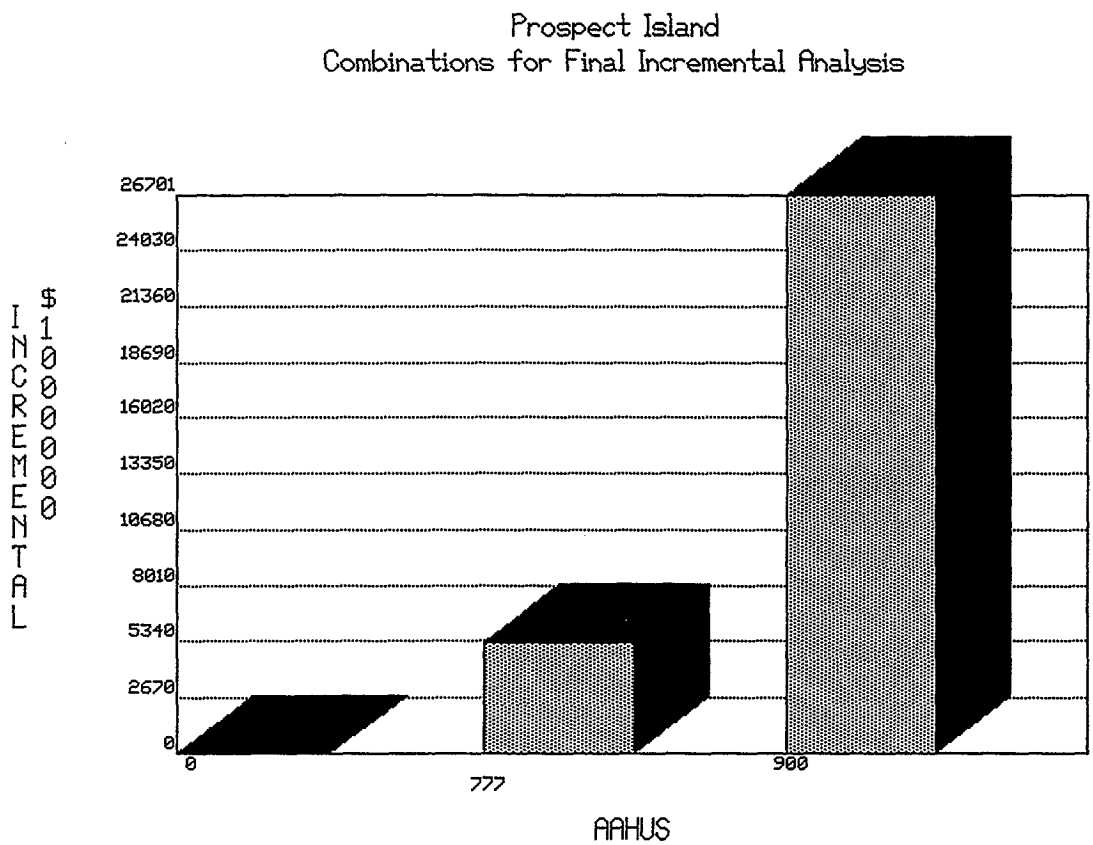
Where:
NA = no action alternative; and
I = alternative under consideration

Next, all alternatives are removed that provide a smaller output level than the alternative with the lowest incremental average cost. The purpose of this step is to smooth out fluctuations in incremental cost per unit as project scale increases such that they are continuously increasing. At this stage, the alternative that produces a lower output than the alternative is noticed with the lowest average cost or any of the other alternatives. Therefore, the alternative that is less efficient in production than the other alternatives is eliminated from further consideration. In this analysis, alternative 3 is less effecient in production than the other alternatives and was eliminated from further consideration.

Finally, the incremental cost, output, and average cost of each alternative was recalculated using the same procedures as in table 4. Table 5 shows the results of this analysis, and figure 3 depicts the incremental average costs for alternative 3 and 5.

Table 5. Final Incremental Analysis.

Alternative	Cost (X $1,000)	Output (AAHU's)	Incremental Cost (X $1,000)	Incremental Output (AAHU's)	Incremental Average Cost (X $1,000 / AAHU)
1 (no action)	0	0	N/A	N/A	N/A
3	$7368638.00	899.70	3286838.00	123.10	26700.6
5	4081800.00	776.60	$4081800.00	776.60	5256.0



Alternative 5. Alternative 3.

Figure 3.

9.0 Summary and Conclusions.

This report presents the results of the cost effectiveness and incremental cost analysis of alternative restoration alternatives for Prospect Island. The objective of this environmental restoration project is to restore degraded ecosystem structure function, and/or dynamic process to a less degraded, more natural condition.

- Create habitat suitable for Federally-listed threatened Delta smelt habitat and proposed threatened Sacramento splittail on Prospect Island,
- Develop feeding, cover, and resting areas for Federally-listed endangered winter-run chinook salmon on Prospect Island,
- Improve waterfowl and shorebird habitat on Prospect Island,
- Provide terrestrial and aquatic habitat for other wildlife species

Three restoration alternatives were compared using the Corps' cost effectiveness and incremental cost analysis procedures. A cost effectiveness analysis showed alternative 4 was non-cost effective. As a result, this alternative was eliminated from further consideration.

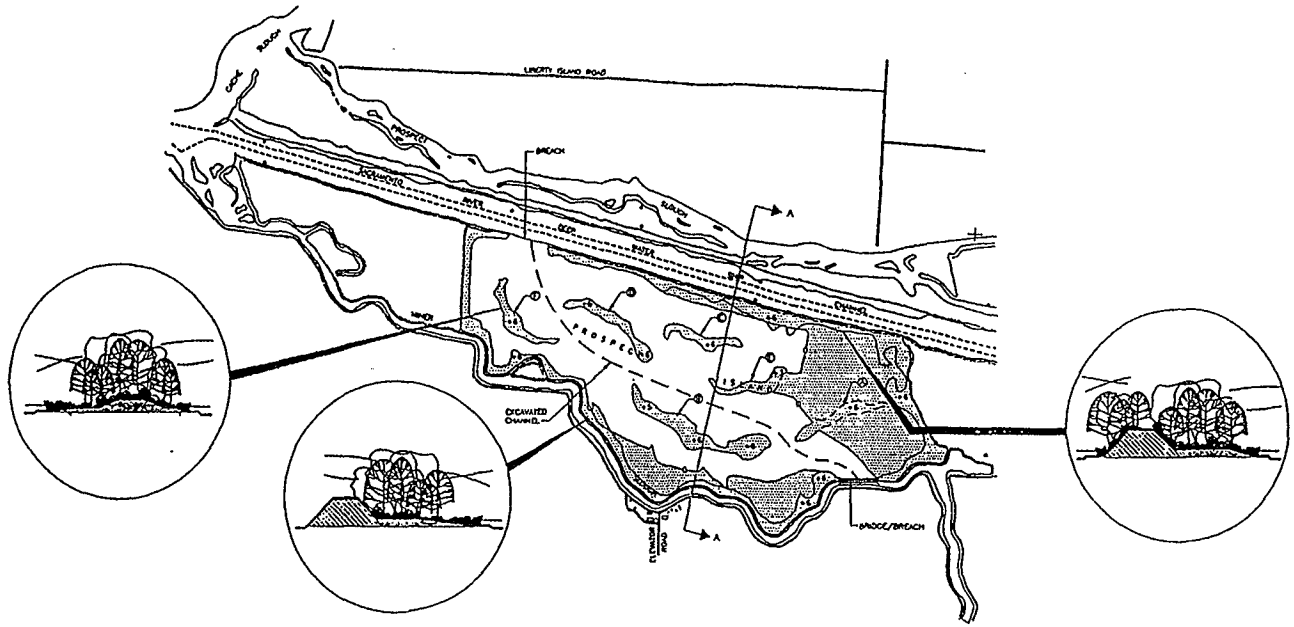
After the cost effectiveness and incremental cost analysis, restoration alternatives 3, and 5 remain. While both alternative 4 and 5 were were cost-affordable to the local sponsor, alternative 4 was screened from further consideration due to the 1997 flooding event. Of the remaining alternatives, alternative 5 produces the greatest number of benefits and was preferred by the local sponsor. As a result, alternative 5 was chosen as the selected plan.

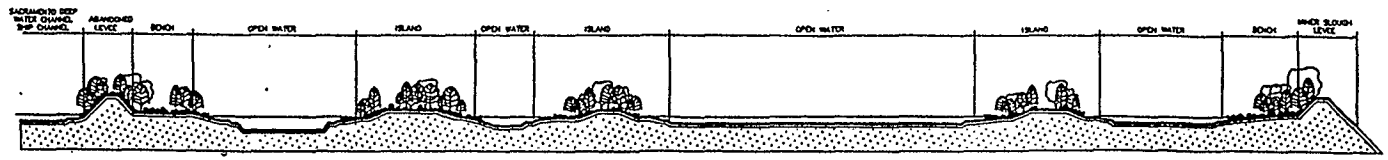
ATTACHMENT A
DETAILED COST ESTIMATES

C-088958

COST			FEATURE
Alternative 3	Alternative	Alternative	
			Breaching
$ 31,000			Breach north end of Miner Slough levee and south end of ship channel levee, provide 250-foot breaches
$ 1,000			Construct signs warning boaters of dangerous underwater hazards at breach locations
			Relocations
$ 17,000			Relocate power poles
$ 17,000			Remove pumps, pipes, miscellaneous structures, one set of power poles, and wiring
			Levees
$ 431,000			Create a 10:1 slope with a 30-foot berm from elevation 0 to 5.5 feet msl on Miner Slough and both cross levees
$ 196,000			Improve the Miner Slough levee road to the Stringer property to convey a similar vehicle load as the ship channel levee road (4-inch gravel road surface only)
$ 225,000			Construct a steel bridge across the breach on the Miner Slough levee to allow passage of private automobiles and trucks
$ 306,000			Provide biotechnical slope protection (emergent marsh vegetation)
$ 108,000			Plant levee bench with riparian/uplands vegetation
$ 41,000			Plant levee bench with riparian/uplands seeding/cover crop
$ 53,000			Plant the water side of the ship channel levee with shaded riverine aquatic habitat
			Islands
$ 1,437,000			Construct islands
$ 463,000			Provide biotechnical slope protection (emergent marsh vegetation)
$ 120,000			Plant islands with riparian/uplands vegetation
$ 61,000			Plant islands with riparian/uplands seeding/cover crop
$ 3,507,000			**Feature cost subtotal**
$ 3,943,000			Lands and damages
$ 25,000			Relocations
$ 5,358,000			Fish and wildlife facilities
$ 55,000			Cultural resource preservation
$ 643,000			Engineering and design (12%)
$ 429,000			Supervision and inspection (8%)
$ 10,453,000			**Total Project First Cost**

PLATES





SECTION A–A

NOT TO SCALE

PROSPECT ISLAND

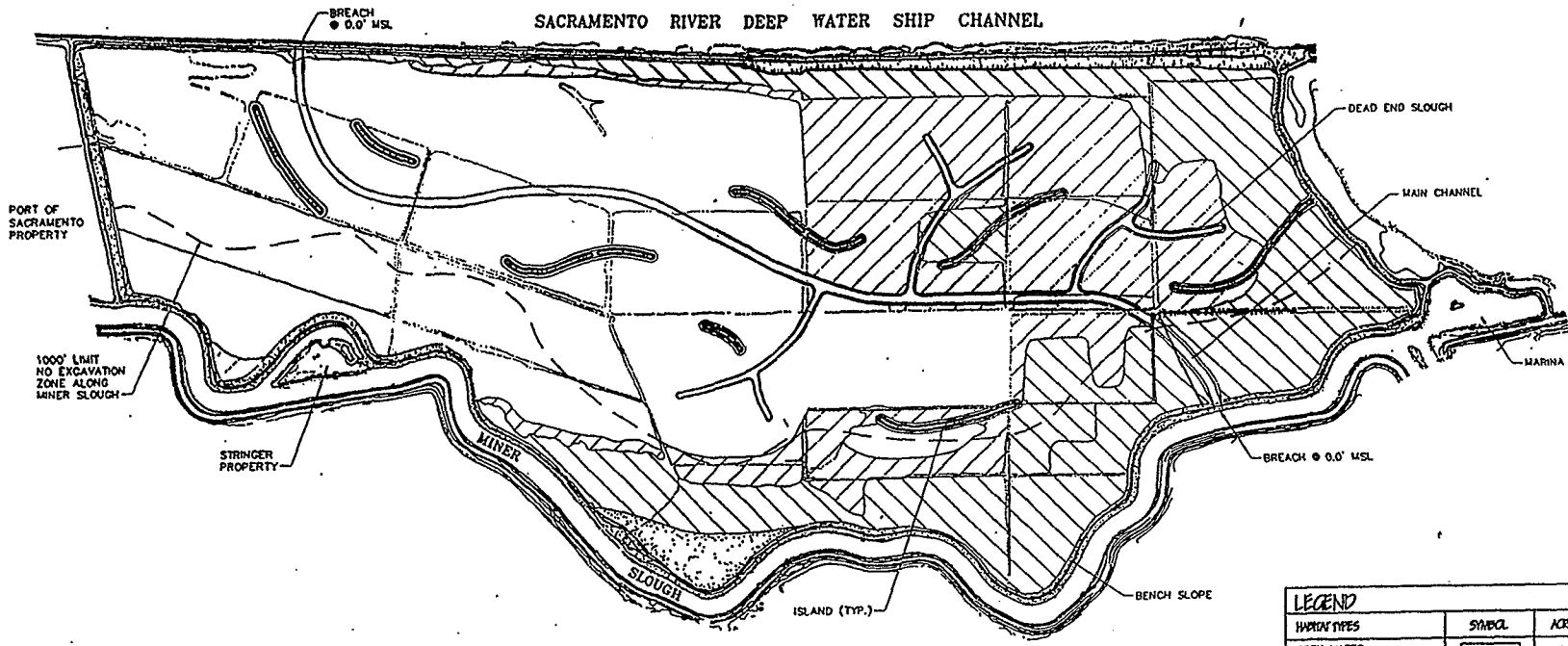
FISH & WILDLIFE HABITAT RESTORATION

STUDY ALTERNATIVE 3

CORPS OF ENGINEERS, SACRAMENTO DISTRICT

PLATE 3

C-088961



LEGEND		
HABITAT TYPES	SYMBOL	ACRES
OPEN WATER (>-1.0' MSL)		665.1
MUDFLAT (@ 0.0' MSL)		4.0
TULE/EMERGENT (0.0' MSL TO 3.0' MSL)		317.0
POTENTIAL TULE/EMERGENT (-0.5' MSL TO 0.0' MSL)		230.0
SRA/RIPARIAN/UPLAND (>3.0' MSL)		99.9
TOTAL ACREAGE:		1316.0

GRAPHIC SCALE

0 600 1200 2400

1" = 600ft.

STUDY ALTERNATIVE 4

PLATE 4

US Army Corps of Engineers Sacramento District

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

SOLANO COUNTY CALIFORNIA

PROSPECT ISLAND 1135 RESTORATION

HABITAT PLAN

Sheet reference number: L1.0

Sheet of

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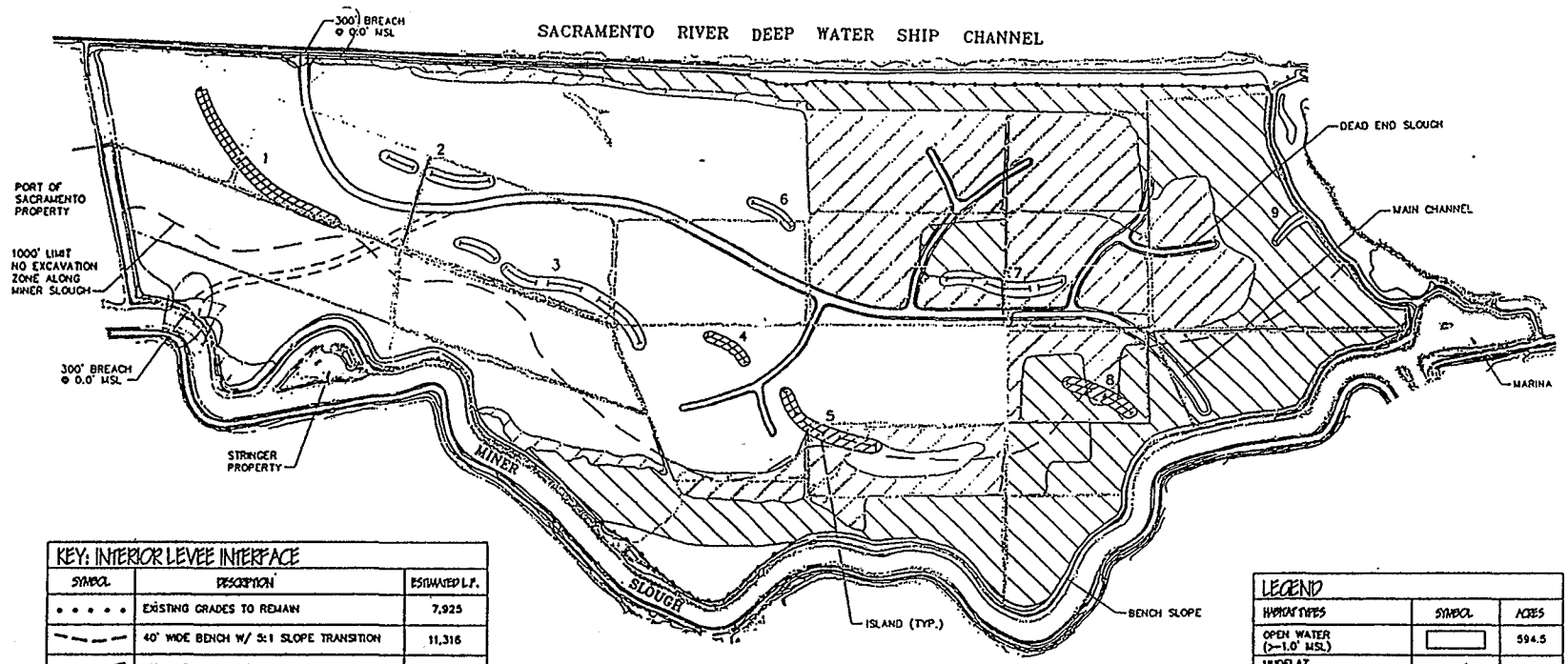


KEY: INTERIOR LEVEE INTERFACE		
SYMBOL	DESCRIPTION	ESTIMATED L.F.
• • • • •	EXISTING GRADES TO REMAIN	7,925
— — —	40' WIDE BENCH W/ 5:1 SLOPE TRANSITION	11,316
———	10' WIDE BENCH W/ 10:1 SLOPE TRANSITION	16,232

KEY: ISLAND CONFIGURATIONS		
ISLAND NO.	CONFIGURATION*	ISLAND LENGTH*
1	BARRIER ISLAND (40' BENCH/ 60' ISLAND/ 20' BENCH)	2,100
2	STANDARD ISLAND (40' BENCH/ 20' ISLAND/ 20' BENCH)	931
3	STANDARD ISLAND	1,801
4	BARRIER ISLAND	517
5	BARRIER ISLAND	928
6	STANDARD ISLAND	511
7	STANDARD ISLAND	1,024
8	BARRIER ISLAND	622
9	STANDARD ISLAND	456

* ESTIMATED CONFIGURATIONS AND LINEAR FEET

× 145'

LEGEND		
HABITAT TYPES	SYMBOL	ACRES
OPEN WATER (>-1.0' MSL)		594.5
MUDFLAT (@ 0.0' MSL)		4.0
TULE/EMERGENT (0.0' MSL TO 3.0' MSL)		333.8
POTENTIAL TULE/EMERGENT (-0.5' MSL TO 0.0' MSL)		230.0
SRA/RIPARIAN/UPLAND (>3.0' MSL)		153.7
TOTAL ACREAGE:		1316.0

GRAPHIC SCALE

0 600 1200 2400

1" = 600 Ft.

PLATE 5 ALTERNATIVE #5

US Army Corps of Engineers Sacramento District

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

SOLANO COUNTY CALIFORNIA
PROSPECT ISLAND 1125 RESTORATION
HABITAT PLAN

Sheet reference number L1.0

C-088963

C-088963

Prospect Island Incremental Analysis Data Sheets

PROSPECT ISLAND
Combinations of Cost & Output

	Management Measures	Cost	Output
1	A0 B0 C0	0.00	0.00
2	A1 B0 C0	7368638.00	899.70
3	A0 B1 C0	4081800.00	768.30
4	A0 B0 C1	4081800.00	776.60

* * * End of Report * * *

C-088965

PROSPECT ISLAND
Combinations Sorted by Cost & Output

	Management Measures	Cost	Output
1	A0 B0 C0	0.00	0.00
2	A0 B1 C0	4081800.00	768.30
3	A0 B0 C1	4081800.00	776.60
4	A1 B0 C0	7368638.00	899.70

* * * End of Report * * *

PROSPECT ISLAND
Least-Cost Combinations for each Level of Output

	Management Measures	Cost	Output
1	A0 B0 C0	0.00	0.00
2	A0 B1 C0	4081800.00	768.30
3	A0 B0 C1	4081800.00	776.60
4	A1 B0 C0	7368638.00	899.70

* * * End of Report * * *

PROSPECT ISLAND
Cost-Effective Least-Cost Combinations

	Management Measures	Cost	Output
1	A0 B0 C0	0.00	0.00
2	A0 B0 C1	4081800.00	776.60
3	A1 B0 C0	7368638.00	899.70

* * * End of Report * * *

PROSPECT ISLAND
Cost-Effective Least-Cost with Incremental Analysis

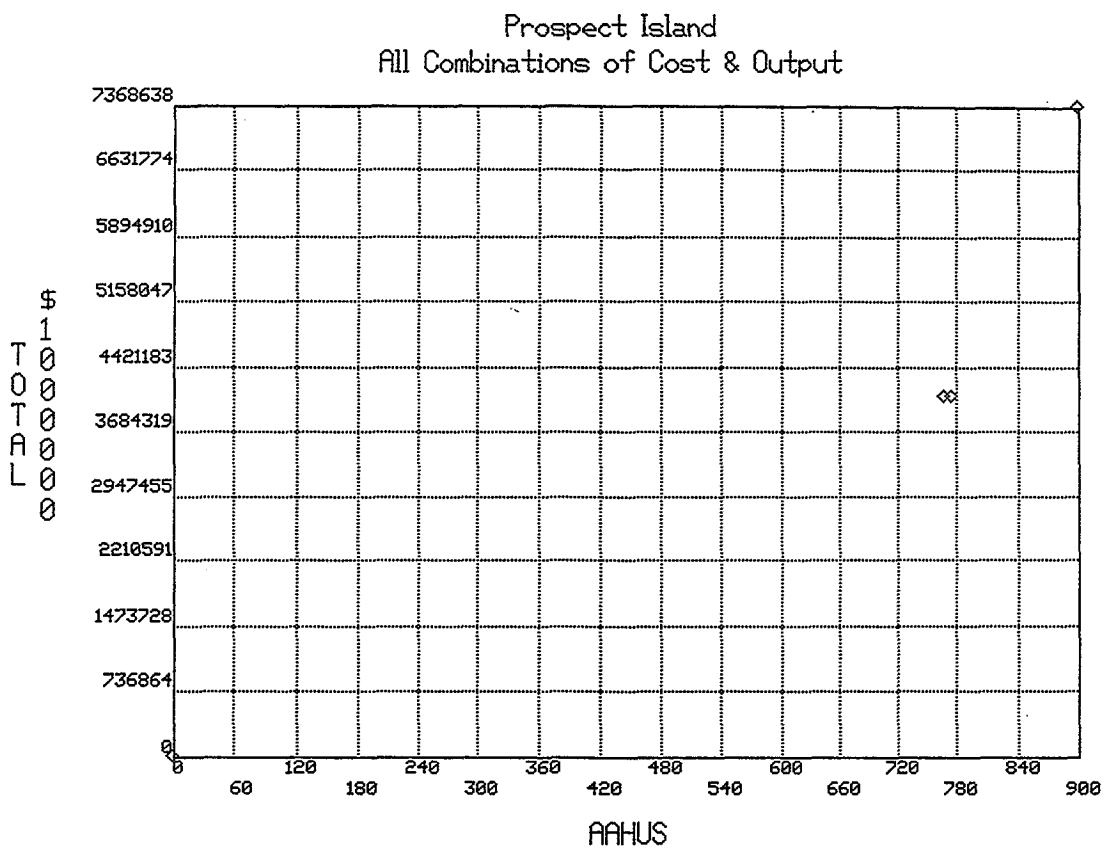
Management Measures	Cost	Output	Incremental Cost	Incremental Output	Incremental Average Cost
A0 B0 C0	0.00	0.00	0.00	0.00	0.00
A0 B0 C1	4081800.00	776.60	4081800.00	776.60	5255.99
A1 B0 C0	7368638.00	899.70	3286838.00	123.10	26700.55

* * * End of Report * * *

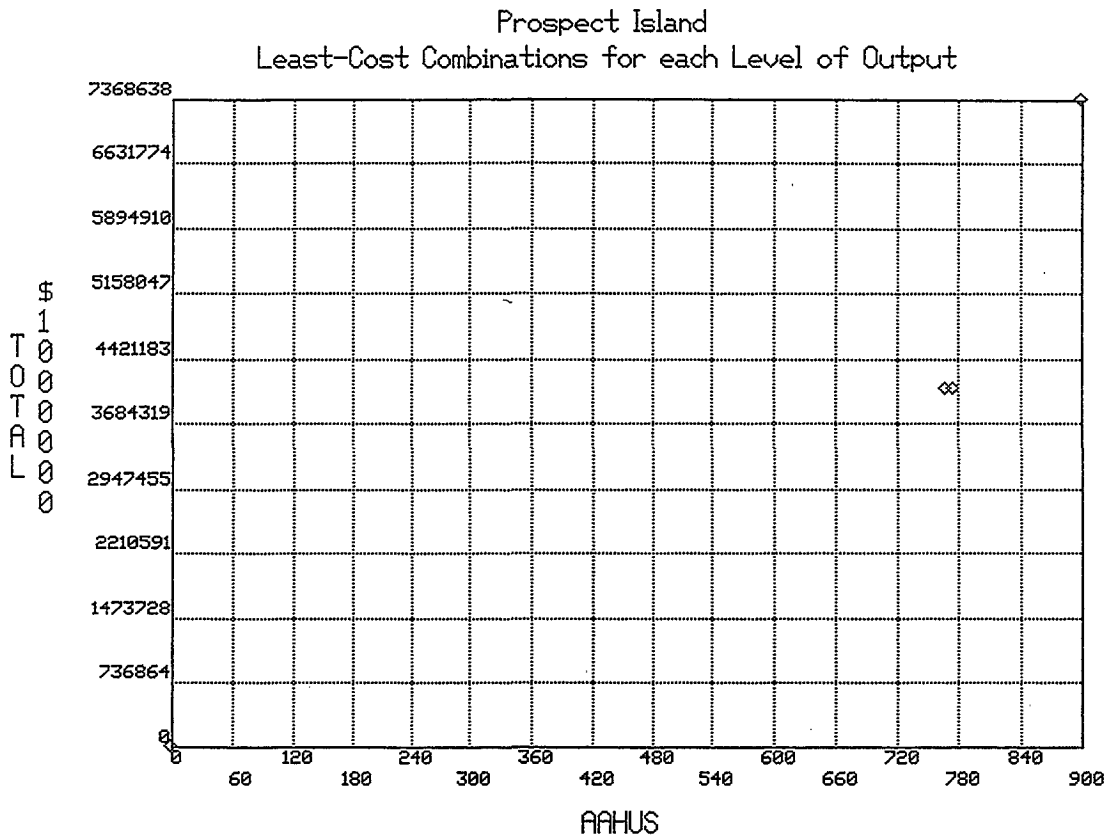
PROSPECT ISLAND
Combinations for Final Incremental Analysis

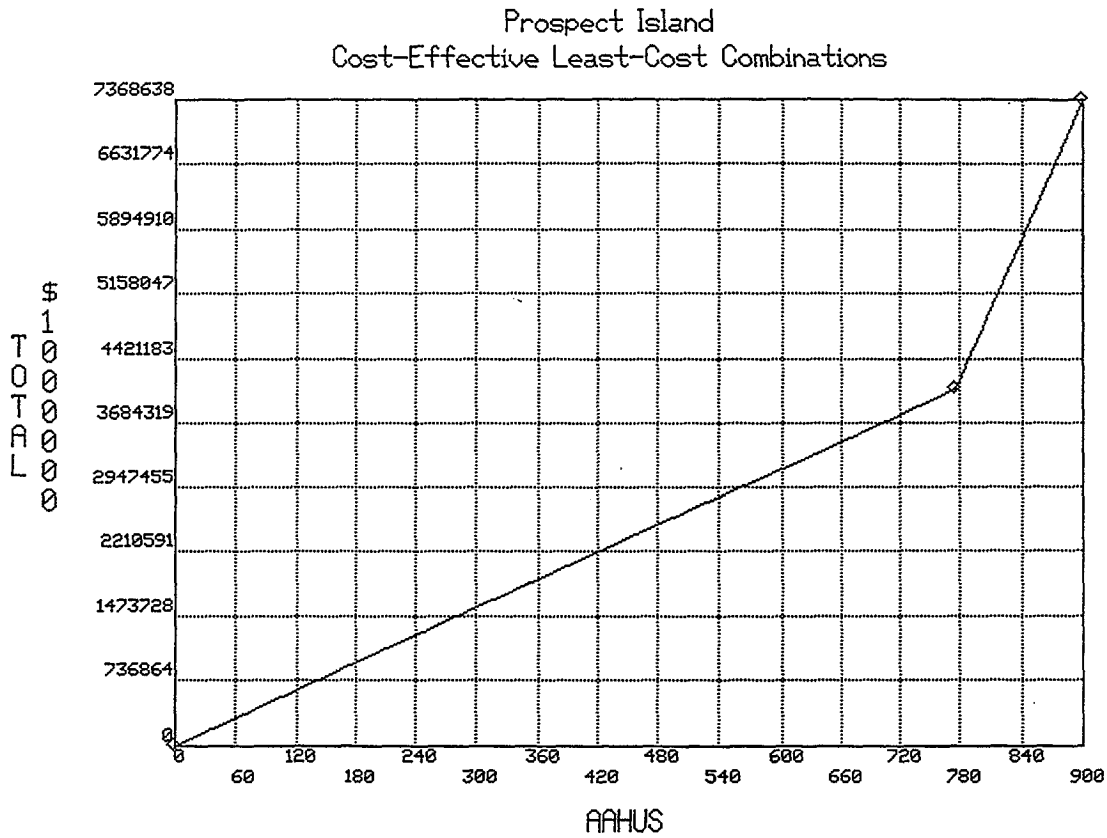
Management Measures	Cost	Output	Incremental Cost	Incremental Output	Incremental Average Cost
A0 B0 C0	0.00	0.00	0.00	0.00	0.00
A0 B0 C1	4081800.00	776.60	4081800.00	776.60	5255.99
A1 B0 C0	7368638.00	899.70	3286838.00	123.10	26700.55

* * * End of Report * * *

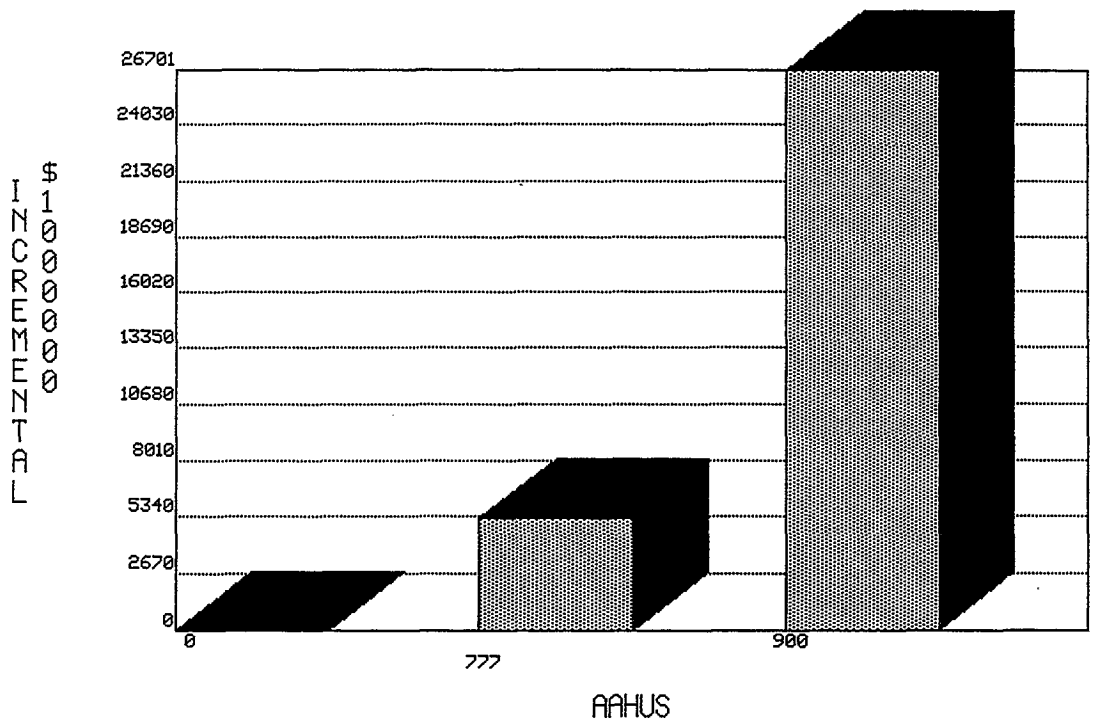

Prospect Island
All Combinations of Cost & Output
7368638
6631774
5894910
5158047
4421183
3684319
2947455
2210591
1473728
736864
0
TOTAL $1000000
0
120
240
360
480
600
720
840
60
180
300
420
540
660
780
900
AAHUS

C-088971


Prospect Island
Least-Cost Combinations for each Level of Output
7368638
6631774
5894910
5158047
4421183
3684319
2947455
2210591
1473728
736864
0
TOTAL $1000000
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
AAHUS


Prospect Island
Cost-Effective Least-Cost Combinations
TOTAL $1000000
7368638
6631774
5894910
5158047
4421183
3684319
2947455
2210591
1473728
736864
0
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
AAHUS

Prospect Island
Cost-Effective Least-Cost with Incremental Analysis



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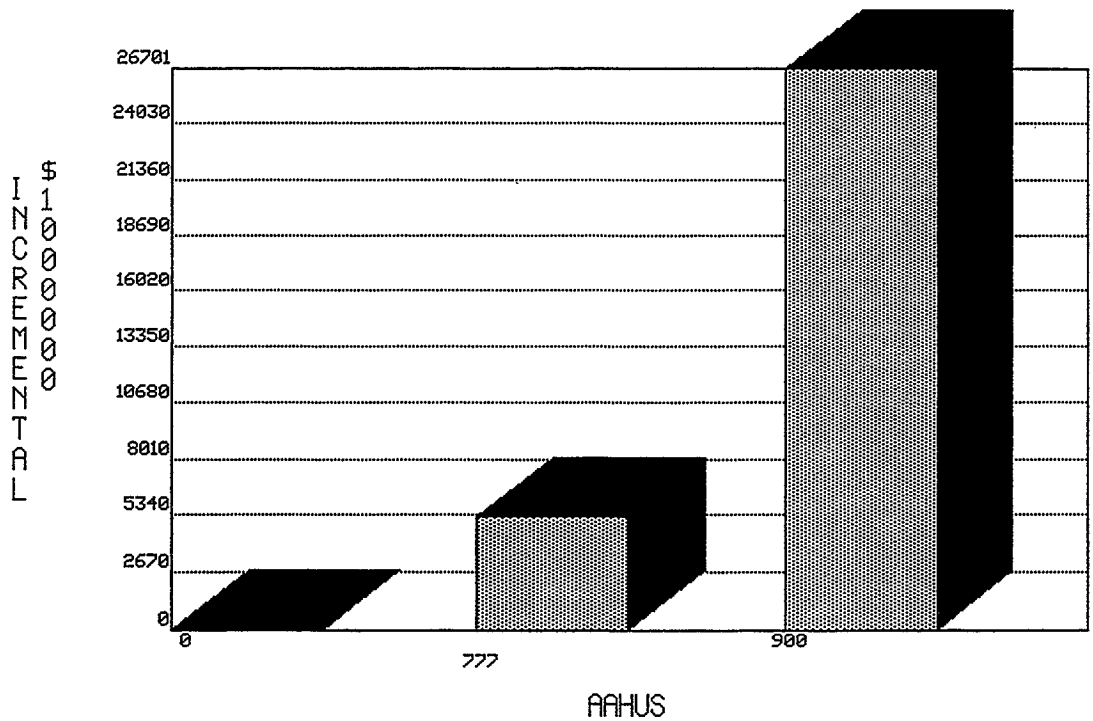
Prospect Island
Combinations for Final Incremental Analysis



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